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CERAMIC SHEARS FOR THE DROP-FORMING MACHINE

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Materials for producing shears for the drop-forming machine are investigated. Aluminum and silicon carbide are chosen as the main components. A new form of shears is designed.

The glass-container industry currently uses high-speed molding methods. Sometimes the efficiency of glass-forming machines reaches 120 units per minute for articles weighing 100 – 150 g.

Liquid glass is cut off using metal shears of a complex configuration made of a high-melting material. The shears are cooled by an air-drop current using special emulsion ACKMOS 4625. The concentrated emulsion is diluted in water in the ratio of 1 : 100. The approximate consumption of the prepared suspension is 1 ton/day per machine, or 240 kg concentrate per annum.

The waste liquid gets on a discharge chute and drops into the granulator. The granulator uses recycled water. The emulsion passing through the cooling tower settles on the pipes in the form of a film and thus decreases the heat transfer level. A simple oil separator cannot filter this emulsion, which is environmentally dangerous.

Metal shears serve for 8 – 10 weeks. After one week of service they require maintenance (cleaning, sharpening).

The cost of the emulsion and shears per two-drop production line are indicated in Table 1.

Considering that the company has 19 production limes, it is easy to calculate that these two expense items amount to an annual cost of about 3.5 million roubles. These are only direct costs. It is necessary to add losses caused by production line downtime and the subsequent yield of defective pieces after the line is restarted.

The purpose of the study performed at the D. I. Mendeleev Russian Chemical Engineering University is the development of a ceramic material that should have sufficient heat resistance, strength, wear resistance, and be not wettable by glass. This could extend the service life of the cutting tools and eliminate the use of the emulsion.

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Together with the engineers from the SVET Glass Container Factory (Mozhga, Udmurtia) we have developed a new form of ceramic shears. Their shape is geometrically simpler. Industrial testing will be performed at the above-mentioned factory.

Having studied published data on the properties of silicon carbide and alumina, we chose these materials as the main components.

Silicon carbide is a compound where covalent chemical bonds prevail. A silicon carbide crystal has a hybridized sp^3 bond with a tetrahedral spatial configuration [1]. This type of bond has the maximum strength. It is shown in [2] that the calculation of the relative values of the energy of hybridized bonds gives good results. Based on its energy parameters, silicon carbide is between diamond and silicon, being nearer to diamond.

All polytype SiC structures (nearly 120 of them have been discovered) have dense spherical packing and differ by their sequences of alternating twin hexagonal layers of carbon and silicon. Each carbon atom is the center of a tetrahedron formed by silicon atoms and vice versa, accordingly, the coordination number of all SiC polytypes is equal to 4. The triple axes of these tetrahedrons are parallel and the tetrahedron bases in the adjacent layers may be parallel or antiparallel [1].

TABLE 1

Cost item	Cost, roubles	Annual need	Total cost, thousand roubles
Blade (1 piece)	1200	24 pieces	28.8
Emulsion ACKMOS 4625 (1 kg)	630	240 kg	151.2

Both alumina and silicon carbide satisfy the requirements imposed on the finished product. The hot extrusion method using yttrium oxide was rejected from the beginning due to its high cost. The finished product ought not to be more expensive than the current analog (heat-resistant metal).

At present we have selected an approximate composition based on silicon carbide and alumina. The strengthening additive in all cases was mixture $MgO \cdot 2SiC$ of grade M5 in the amount of 3%.

A series experiments has been carried out varying the $SiC : Al_2O_3$ ratio from 3 : 7 to 1 : 1. Firing was performed at a temperature of 1400°C. The fired preforms were measured to determine their strength, open porosity, and density. As the content of SiC increases, such parameters as shrinkage, water absorption, and open porosity decrease, whereas apparent density and strength increase.

The wetting angle was determined using clear container glass BTs-1 milled to a particle size of 1 – 5 μm. A pyramid of milled glass was placed on each ceramic sample. The samples were inserted into a furnace for 10 min at a temperature of 1200°C. Samples 5 mm thick did not become deformed, either on being placed into the hot medium, or after their removal from the furnace, even when they were placed on a cold metal surface. The result was always identical: a negative wetting angle (140°). Furthermore, after cooling the glass drop flaked and dropped off, i.e., it did not become sealed to the ceramic sample.

The preliminary experimental results indicate that the material is suitable for making cutting tools for the drop-forming unit used in glass container production.

REFERENCES

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